A METHOD FOR THE LONG-TERM PRESERVATION OF MEAT AND THE MEAT PROCESS THEREBY

BACKGROUND OF THE INVENTION

TECHNICAL FIELD

The present invention relates to a method for preserving raw meat and more specifically relates to a method for preserving raw meat by exposing the meat to an atmosphere consisting essentially of carbon monoxide.

BACKGROUND ART

It is well known in the meat processing industry that from the time animals are slaughtered, measures must be taken to preserve the meat and prevent it from becoming rancid or spoiled. The measures to preserve raw meat must be implemented and carried through from the time the animal is first slaughtered through the time the meat is purchased and ultimately consumed by the purchaser.

Historically, preservation of the freshness or quality of the meats has been practiced for hundreds, if not thousands of years. Early preservation techniques of meat took the form of drying or "jerking" meat and packing or storing

cuts of meat in salt. This method, while somewhat effective for preserving meat and keeping it from becoming spoiled, had many drawbacks not the least of which was the incorporation of large amounts of salt into meat slated for human consumption.

The use of additives or preservatives such as nitrates and nitrites to meats is another common technique for preserving meat over time. However, there is ever increasing evidence that such additives may have harmful, even carcinogenic drawbacks. These drawbacks detract from the use of these compounds as mechanisms for the long term preservation of meat.

With the introduction of reliable means for refrigeration, i.e., the ability to maintain a low temperature regardless of the external environment, the long-term preservation of raw meat has been greatly enhanced and greatly increased the duration of the preservation. Frequently, in modern meat processing, animals are slaughtered at one place which can be remote from the point of sale and the eventual consumer, and as much as a week can pass before the meat is actually consumed. This lag between the slaughtering of the meat and its consumption requires that the meat be constantly maintained under refrigeration in order

to preserve its quality and prevent its degradation over this time period.

For example, an animal (a cow) may be slaughtered and cut into halves or quarters which are then forwarded to a wholesaler or retailer where they may be divided into smaller cuts such as steaks or roasts. During the transfer of the meat from the slaughter house to the wholesaler or retailer, the meat must be maintained, frequently the meat is frozen in order to preserve its quality. After the meat has been divided into cuts for sale to the eventual consumer, it must also be maintained under constant refrigeration in order to preserve its quality. Under this distribution scheme, it can be from a few days to more than a week before the meat is purchased and consumed. It, therefore, becomes evident that this constant requirement for very low temperatures greatly contributes to the cost of meat.

Another example of the costly disadvantages of very low transportation and storage temperatures can be illustrated by practice of long distance overseas shipment and distribution of frozen meat. Today, freezing is a standard method of distributing meat processed in one region of the world to another region where it is to be

consumed. Overseas shipment of frozen meat is both very costly and thawed meat obtained by this method is no longer considered to be "fresh" meat. That is, once a piece of meat has been frozen, by definition it is no longer considered to be "fresh." A method of overseas transportation of meat which maintains the "freshness" of meat transported for distribution would be highly desirable. Since the only method available for long distance overseas distribution of meat is by shipping frozen meat, no method currently exists which would allow for the overseas distribution of "fresh," unfrozen meat.

Transportation of slaughtered meat from the slaughter house to the wholesaler or retailer requires the use of some form of refrigerated transportation, such as refrigerated tractor-trailer trucks. This is a costly mode of transportation since it requires specialized equipment and extra fuel to provide and maintain refrigeration.

In addition to preserving the overall quality and fitness of the meat for consumption, other methods have been derived which are aimed at preserving the color of fresh meat. That is, methods have been developed which maintained for example, the red color of fresh meat, such as beef.

Typical examples of methods for treating raw meat to preserve the color of the meat are disclosed in United States Patent Nos. 3,459,117 to Koch et al., 4,001,446 and 4,089,983 both to Hood, and 4,522,835 and 3,930,040 to Woodruff et al. All of these patents disclose methods or processes for preserving or maintaining the color of meat such as beef, poultry or fish.

Both of the Hood references disclose methods of exposing an animal protein source to a reducing agent and then an environment of carbon monoxide in order to preserve the bright red color of protein source. Additionally, the Hood et al. references only treat slurries of the protein source as this is required for saturation by the carbon monoxide. The source is then mixed with the remainder of the food stuff to prepare a moist dog food. Further, the references are concerned only with the application of carbon monoxide in order to preserve the color of product and both require

subsequent processing, such as canning or heat sterilization, in order to preserve the actual quality and freshness of the product. Additionally, the Hood '983 reference discloses the addition of a sufficient amount of microbiological and bacteriological inhibitors to further preserve the product.

The Woodruff et al. '835 reference discloses a process for maintaining a good color and the freshness meat by first exposing meat to an atmosphere with a small amount of oxygen and then exposing the meat to a modified atmosphere containing a small amount of carbon monoxide to effect the conversion of myoglobin to carboxymyoglobin. A third required step is the maintenance of the meat in an atmosphere of higher than 10% carbon dioxide.

The Woodruff et al. '040 patent discloses a process for storing or shipping fresh meat in a modified gaseous atmosphere. The process requires maintaining refrigerated meat in an artificial atmosphere composed of oxygen, carbon dioxide and carbon monoxide as well as nitrogen. The carbon monoxide may be removed from the modified material after the meat has been treated for at least one hour.

The Woodruff et al. patents teach maintaining the color in meat by treating the meat with a mixture of gases including carbon monoxide. That is, the Woodruff et al. patents teach chemical alteration of the surface of the meat to maintain the color of the meat and utilize refrigeration for meat preservation. Additionally, the Woodruff et al. patents teach the treatment of meat using a gaseous mixture of carbon monoxide, oxygen, carbon dioxide, and nitrogen. This method of treatment results in the creation of a storage environment which has low oxygen concentration and a carbon dioxide concentration of approximately ten percent. This type of gaseous mixture creates optimal growth conditions for the growth of microaerophil bacteria such as *Helicobacter pylori* and *Campylobacter jejuni* which are known to be pathogens which cause widespread gastroenteritis. The Woodruff et al. method of treating meat does maintain the color of fresh meat, however, the Woodruff et al. method has the disadvantage of accelerating bacterial contamination of meat treated by the Woodruff et al. method, thus shortening the storage life of the meat treated thereby.

The Koch et al. '117 patent discloses a cover useful for treating fresh red meat with carbon monoxide in order to maintain the bright red color of the meat. Koch et al., teaches a cover comprised of two films which are sealed together around the edges and which confines a quantity of carbon monoxide gas therebetween. Both film layers are substantially carbon monoxide impermeable when dry, however; when the film is brought into contact with a freshly cut sample of red meat, the moisture in the meat wets the film and transforms the film into a carbon monoxide permeable structure. The carbon monoxide then contacts the meat sample thereby causing the meat to maintain its desired red color.

The Australian Patent Document No. AU-A-18559/92 to Tamayama et al., discloses a method for maintaining and improving the quality of meat by causing meat to contact and absorb carbon monoxide gas in a sealed container and then requiring removal of the carbon monoxide gas from the container. Exemplifying the criticality of the removal of the carbon monoxide gas from the container, the patent requires that the carbon monoxide gas within the container be sucked and discharge by means of a pump.

Heretofore, the treatment of raw meat with carbon monoxide has been taught simply as a mechanism for preserving the color of the meat and, not as a mechanism for the long-term preservation of a meat sample over time in a fresh, non-frozen form.

While the above-disclosed patents teach the exposure of raw meat to gas mixtures containing carbon monoxide or the exposure of meat slurries to carbon monoxide in combination with other steps, they fail to teach a simple method of exposing raw meat solely to carbon monoxide.

In order to overcome the problems and deficiencies of the prior art methods, it is desirable that a method of preserving raw meat be introduced which eliminates the cost and associated problems with the prior art preservation techniques.

Applicant has developed a single step method for preserving meat by exposing raw meat to an atmosphere consisting essentially of carbon monoxide and, then, storing the meat in a sealed container. Unlike prior art preservation methods, no additional steps, compounds or additives are required in order to prevent the growth of microbiological or bacterial organisms.

SUMMARY OF THE INVENTION AND ADVANTAGES

According to the present invention, a method for preserving meat by exposing raw meat to an atmosphere consisting essentially of carbon monoxide is shown. Meat treated according to the present invention may not require any form of subsequent refrigeration under certain conditions and time constraints and can be stored for long periods of time following treatment with the carbon monoxide without significant bacterial growth, without freezing, and without a loss in meat quality.

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BRIEF DESCRIPTION OF THE DRAWINGS

Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIGURE 1 is a bar graph of the relationship between aerobic bacterial growth on a fresh meat sample stored at 22-30°C over time in either a CO treated environment or an air only environment;

FIGURE 2a is a histogram illustrating preservation duration of CO preserved meats and air treated meat preserved at 5 +/- 3°C as determined by Microaerophil growth;

FIGURE 2b is a histogram illustrating preservation duration of CO preserved meats and air treated meat preserved at 5 +/- 3°C as determined by total viable aerobic bacterial growth;

FIGURE 3 is a graph illustrating spectral analysis of the amounts of hemoglobin in the blood of cats that consumed either CO treated meat or air treated meat;

FIGURE 4 is a photograph illustrating meats, the colors of meat treated with (A) vacuum only, (B) N_2, (C) air, and (D) CO;

FIGURE 5 is a photograph illustrating the color change in meat treated without CO (left) and meat treated with CO (right);

FIGURE 6 is a photograph illustrating the internal color change of meat treated without CO (left) and meat treated with CO (right);

FIGURE 7 is a photograph illustrating the color change of a piece of fresh CO treated meat stored at 5°C for three days;

FIGURE 8 is a photograph illustrating the same meat sample shown in Figure 7 stored with CO at 5°C for ten days;

FIGURE 9 is a photograph illustrating a transverse cut of the meat sample shown in FIGURE 8 made at 7 cm from the edge showing homogenous bright red color;

FIGURE 10 is a photograph illustrating transverse cuts of CO treated (left) and frozen (right) meat samples after twelve days of storage;

FIGURE 11 is a photograph of the transverse cuts of meat shown in FIGURE 10 after cooking;

FIGURE 12 is a photograph illustrating transverse cuts of the cooked meat samples shown in FIGURE 11; ~~and~~

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FIGURE 13 is a photograph illustrating a section of CO treated meat as shown in FIGURE 10, following exposure to open air at 5°C for two weeks, at the end of this two week period, the meat sample was ground, a 200 gram "hamburger-like" sample was cooked and released CO was measured, (top) prior to cooking, (bottom) following cooking.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Generally, the present invention provides a method for preserving meat by exposing raw meat, processed or not, to an atmosphere consisting essentially of carbon monoxide (CO) and, subsequently, storing the meat in a sealed container.

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For the purposes of the present invention, the term "meat" is defined to include all types of fresh meat and fresh poultry such as beef, pork, veal, lamb, chicken, turkey, fish and the like. The meat may be in the form of carcasses, primals (e.g., quarters), subprimals (e.g., top round), or retail cuts (e.g., steaks, ground meat and roasts). The process is also effective on whole animals including, but not limited to, cattle, chickens, and fish. Unlike prior art methods, the meat need not be slurried or

otherwise pretreated. "Fresh meat" is defined as a meat article which has not been frozen and subsequently thawed before its sale or consumption.

By preserving, it is meant that the meat maintains a pleasing color, does not spoil and develop a foul smell, bacterial growth is significantly inhibited or retarded, and remains completely pleasing, edible and consumable by humans and other animals. Preservation is not only maintained on the surface of the meat, but also throughout the entirety of the meat. That is, the meat is preserved throughout the thickness of the meat. "Pleasing color" implies that the color of the meat, preserved by the method according to the present invention, is such that it stimulates the appetite to consume the meat. That is, the color and odor of the preserved meat is such that a consumer would be enticed by the meat and would want to consume the meat. Again, meat color is also preserved throughout the thickness of the meat.

The term "without freezing" is defined as storing the meat wherein the temperature is kept between approximately -2 to 30°C. The term "without freezing" also excludes the use of any device or method for freezing the meat. Such

devices include, mechanical or electrical refrigeration devices such as refrigerators, freezers, coolers, and chillers. This term also excludes the preservation of meat by freezing through storage on ice.

Ins A6 Exposing raw meat to an atmosphere consisting essentially of carbon monoxide is defined as bringing into intimate contact both carbon monoxide gas and the meat being treated. The atmosphere preferably consists of carbon monoxide. This term also includes the complete conversion of myoglobin present in the meat sample to carboxymyoglobin and, the complete conversion of myoglobin to carboxymyoglobin/carboxyhemoglobin in fish. The meat is completely immersed or saturated with carbon monoxide.

More specifically, a cross-section of meat is completely immersed in or saturated to its core with carbon monoxide from the exposed surfaces through the entire cross-section (thickness) including its core region and retains the carbon monoxide until the meat is cooked. Thus, as stated above, the meat is preserved throughout its thickness.

Carbon monoxide is inherently a very inert gas. Carbon monoxide is relatively more inert than nitric oxide gas (NO) released from nitrites which have been used as preservatives for meat for several hundred years. Carbon monoxide is a normal metabolite in the body. It is produced indigenously as a product of heme catabolism (mostly the breakdown of hemoglobin). Carbon monoxide is further converted to carbon dioxide and is released from the body in that form. Recently, it has been found that normal metabolism utilizes carbon monoxide as a neurological messenger. (Baranaga, 1993) The high toxicity of carbon monoxide generally stems from its ability to compete with oxygen for binding to hemoglobin.

Practically all of the carbon monoxide (over 99.9%) taken up by meat will be maintained as hemoglobin and myoglobin (Hb/Mb) bound forms. The distribution of carbon monoxide in the meat is assumed to be about half in each globin type. This estimation is based on the fact that mammalian muscles contain approximately two-thirds of their globins as hemoglobin and one-third as myoglobin, but when muscle becomes packed as meat, it looses a portion of its hemoglobin.

Both hemoglobin and myoglobin bind carbon monoxide much more strongly than oxygen. Native Hb/Mb contain iron and divalent oxidation state (Fe^{+2}) and only in this form are Hb/Mb capable of binding the gas ligands O_2, NO, and CO. Following any change in the iron oxidation state, Hb/Mb loose their CO binding ability. Denaturation of the proteins (e.g. by heat) can also result in loss of CO binding potential (as well as other ligands).

Hb/Mb are established catalyzers of the oxidation process in biological tissues. Under regular atmospheric conditions, the Hb/Mb in fresh meat, which are in their native form, exist in a O_2 bound form, the so-called oxy-Hb/Mb. Oxy-Hb/Mb tends to undergo autooxidation to met-Hb/Mb namely the oxidation of the Hb/Mb divalent iron to Fe^{+3} can concomitantly with the formation of superoxide anion O_2^- by the reaction

$$\text{oxy-Hb/Mb } (Fe^{+2}\ldots O_2) \rightarrow \text{Met Hb}(Fe^{+3}) + O_2^-$$

The superoxide anion is unstable and further forms hydrogen peroxide (H_2O_2) which together with Hb/Mb acts as a highly active peroxidation system. Met-Hb/Mb no longer binds any of the gas ligands including carbon monoxide. On the other hand, the Met-Hb/Mb are catalyzers of

oxidations. Unlike the case of oxygen bound to Hb/Mb, in a carbon monoxide bound form, Hb/Mb are protected from autooxidation. Therefore, to protect meats from autooxidation, carbon monoxide is best applied to fresh meat.

It is thought that the mechanism for carbon monoxide preserving of meat is the much greater affinity of myoglobin for carbon monoxide than for oxygen. Following this mechanism, carbon monoxide out-competes oxygen for binding onto myoglobin molecules within the meat structure. By completely displacing oxygen, the micro-environment of the meat becomes more anaerobic and, thereby, prevents or inhibits the growth of aerobic microorganisms, such as *Escherichia coli*, which are responsible for spoilage and degradation of fresh meat and illness. Anaerobic bacterial growth, such as *Microaerophils*, is also inhibited when this method is utilized. This proposed mechanism of carbon monoxide action is merely for illustrative purposes and in no way should be construed as limiting.

The ability to inhibit or prevent the growth of microorganisms allows for the extended storage of meat treated according to the present method. That is, meats treated according to the present invention have a longer storage life and remain both viable and edible in a non-contaminated form for periods longer than those available using current preservation techniques.

In the practice of the present invention, meat samples are placed in an enclosure or container and flushed or exposed to carbon monoxide gas.

The process consists of two stages:

(A) "Meat packing" which refers to introducing the meat into a confined CO atmosphere. "Packed meat" refers to meat which has undergone the meat packing part of the process.

(B) "Meat preservation" which involves maintaining the "packed meat" until it reaches the consumer.

<u>Meat Packing</u>

The container for treatment, storage, and transportation of meat by the method of the present invention can be constructed of various gas-impermeable material such as plastic, metal, and

other materials known in the art. The container can be equipped with both gas inlet and outlet channels which can be opened to allow the influx of gas (CO) or closed in order to render the container sealed.

A suitable container would be capable of maintaining a seal to prevent the escape of carbon monoxide gas from the container. For example, the container can be a sealed room in which large amounts of meat may be treated at a given time, the container can also be a smaller sealable container or chamber. Preferably, the container is of larger volume than the volume of meat being treated to allow for a greater volume of carbon monoxide gas to contact the meat sample.

In a preferred embodiment of the invention, meat samples are treated and stored within plastic bags constructed of a material which is safe for the storage of food products such as polyvinylidene chloride. Preferably, the plastic bags will be constructed of a material that is impermeable to the passage of gases therethrough. Thusly, the meat is maintained in the carbon monoxide atmosphere within the bag (container) during storage.

After a piece of meat to be treated according to the method of the present invention is placed in a suitable container, the container is then filled with the CO gas. The addition of the CO gas can be accomplished in any suitable manner; however, the preferred methods include first removing the gas atmosphere present in the container (usually air) by using a vacuum pump, as is well known in the art, to remove any gases present and the container. The container is then filled with CO from a source such as a gas cylinder.

The container is connected to the CO containing cylinder and CO is introduced. Input and output pressures are measured during the filling process. The input pressure is generally maintained within a range of approximately 1.5 to 5.0 atmospheres. The preferred pressure is approximately 2.0 atmospheres. Upon reaching the preferred pressure in the output, the gas flow is stopped and excess gas is allowed to escape until the pressure within the container reaches approximately 1.0 to 1.2 atmospheres. The preferred gas pressure in the container is approximately 1.1 atmospheres.

During the gas filling operation, the ambient temperature of the surrounding can be maintained between -2 to 37°C.

The parameters that govern gas filling or exposure time vary depending on the pressure of the gas input, the dimensions of the inlet and outlet channels, and the dimensions of the container.

For meat packing, exposure of only the surfaces of the meat to carbon monoxide is generally required. However, for the purposes of meat preservation, the gas filling time should be long enough to allow for a sufficient amount of CO gas to be completely absorbed (throughout its thickness) into the meat undergoing treatment. That is, enough CO gas is flushed through the container to allow for the complete penetration and protection of the meat being treated.

The gas filling time generally ranges from approximately one to thirty minutes with the preferred filling time being approximately five minutes. For the purposes of this invention, exposure time is defined as the gas filling time. Again, it should be noted that the length of exposure of the carbon monoxide to a meat sample will vary depending on the size of the meat sample and the weight of the meat sample being treated.

That is, a larger and heavier meat sample will require a longer period of exposure to the carbon monoxide in order to achieve long-term preservation. In other words, a larger meat sample will require a longer exposure to carbon monoxide in order to properly preserve the meat sample without the freezing.

The temperature during the carbon monoxide exposure is preferably between -2 and 37°C and can vary depending on the temperature selected to in order to carry out the method.

Meat treated as previously described above generally contains from 5 to 100% by weight or volume of CO gas. The preferred volume of CO in the treated meat is approximately 30% of the weight of the meat (e.g. 30 ml for 100 grams of treated meat).

Under the meat preservation method of the present invention, the meat surface is initially contacted with the CO gas. Since the surface of the meat is the most prominent site for the presence of bacteria, the meat treated by the method of the present invention is immediately protected. Further, while sealed in the container, penetration of the CO gas continues until the entire meat mass has been penetrated and, thereby,

protected. This total penetration allows for the complete substitution of both hemoglobin and myoglobin by the carboxy forms of these compounds as is shown in the following examples. The total CO treatment of the meat throughout its thickness also enables meat which has been treated according to the present invention to maintain a pleasing color for extended periods of time after the meat has been removed from the packaging or container in which it was treated. That is, as shown in the following examples, meat treated according to the present invention can be transported, unpacked, and then maintained in a fresh form for a further extended period of time without a loss of color or quality.

The above discussion provides a factual basis for the use of the present invention as a method of long-term preservation of meat at different temperatures without freezing. The examples also demonstrate the preservation of the meat after undergoing the treatment of the present invention. The methods used with and the utility of the present invention can be shown by the following examples.